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No. 1

CRETACEOUS GEOLOGY OF LOWER CALIFORNIA*

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INTRODUCTION

During the last few decades a number of geologists have visited different parts of Lower California and have brought back much general information concerning the region. Most of the reports made by these visitors have dealt largely with the physical aspects of the country, or they have contained only general accounts of their geological observations, with a minimum of paleontological data.

In 1867 Wm. M. Gabb traversed the peninsula from Cape San Lucas to San Diego, a distance of 775 miles, making on his way north various excursions to the eastern and western coasts. His excellent account is, however, only general, and is based more upon his impressions of the country than upon scientific or convincing data.[1]

Since then W. Lindgren,[2] S. F. Emmons and G. P. Merrill,[3] and various others have visited portions of the peninsula, and have published their accounts. In 1921 N. H. Darton[4] accomplished a traverse

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[1] Wm. M. Gabb, Rept. Min. Res. U. S., 1868, pp. 630-639. A more detailed account is given in J. Ross Browne, Resources of the Pacific Slope, Appendix, pp. 82-102, D. Appleton & Co., N. Y., 1869.

[2] W. Lindgren, Proc. Calif. Acad. Sci., ser. 2, vol. 1, 1888, pp. 173-196.

[3] S. F. Emmons and G. P. Merrill, Bull. Geol. Soc. Amer., vol. 5, 1894, pp. 489-514.

[4] N. H. Darton, Jour. Geol., vol. 29, 1921, pp. 720-748.

of a great part of its length, and his account contains numerous sectional sketches across the peninsula showing its geologic constitution and structures in a concise manner.

More recently considerable information concerning the Cretaceous rocks of this region has been obtained from the unpublished observations of G. D. Hanna, from published reports of the Marland Oil Company,[5] from the collections and reports made by Manuel Santillán and Tomás Barrera of the Mexican Geological Institute, and also from the collections and accounts of Charles H. Sternberg of San Diego; most of this information is embodied in the present paper, although abbreviated.

It has been claimed that much of the surface of the peninsula is underlaid by Cretaceous rocks, and although this view has been generally accepted, the basis for it appears to be little more than inference drawn from lithological appearances, or from other data not paleontological. The results are accordingly not always satisfactory, and have been misleading, as will be seen later.

Gabb described a yellowish, horizontally bedded sandstone as covering a large part of the southern half of the peninsula, which he called the "Mesa sandstone," and which he provisionally classed as Miocene, apparently from the lithological appearance. Concerning these sandstones he said, in part (p. 633, etc.):

> "After leaving the granite ranges south of La Paz the whole appearance of the country changes, and with it the geological structure. The granite itself has disappeared, only to show itself as one or two insignificant outliers, and in its place come enormous deposits of sandstone forming flat-topped mountains, ragged and precipitous along the east coast, sloping off so gradually toward the Pacific as to merge insensibly into the broad low plains of the west. . . .
>
> "The mesa sandstones are easily distinguished from the overlying rocks by their coarser grain, greater compactness, and above all by their being highly metamorphosed along the greater part of their eastern margins. Another marked feature is the presence of large quantities of boulders and pebbles of volcanic rocks embedded in them, sometimes to such an extent as to form even a preponderance of the bulk of the strata. . . . "

The surmise that the "Mesa sandstone" is of upper Cretaceous age began with the account by Lindgren of the beds at Todos Santos Bay near Ensenada. Lithologic resemblances and general geologic facts in his possession induced him to suggest their identity with the "Mesa sandstone" of Gabb. Other geologists have since adopted this view, but according to the sections drawn by Darton, the "Mesa sandstone" is underlaid by "yellow beds," and sections nos. 19 and 20, northwest of La Paz, show both to be underlaid by Eocene strata.

As the character, classification and distribution of the Cretaceous rocks found on the peninsula, proved and reported, constitute the chief concern of the present paper, a brief account of them and their geological background may be summarized in the following pages, as they have been described by others.

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[5] Carl Beal, Bol. del Petroleo, vol. 17, no. 16, and vol. 18, no. 1, 1924.

Maps. The usual atlas maps of Lower California are nearly worthless for even general reconnaissance work. Therefore, we have given below a list of those which we have used and have found to be generally dependable.

1. For the outlines of coasts and islands and general navigation purposes the charts issued by the Hydrographic Office of the U. S. Navy are indispensable.[6] The general chart covering the whole of Lower California and the Gulf of California is No. 1006.

2. An excellent map of Lower California, (scale 1:1 M), showing most of the important roads, trails, towns, villages and the topography, (contour interval 100 meters), was published by the American Geographical Society, New York. The lower part of the peninsula north to Scammon Lagoon was published in 1923 as a "provisional edition." The northern part, still "provisional edition" appeared in 1928. These maps are marred by a few typographical and other errors, which, presumably will be corrected in the final edition; the northern section, for instance, is labelled "South America."

3. Carl Beal and associates in the Marland Oil Company made extensive geological explorations in Lower California about 1920-1923, in connection with a concession which had been granted to the company. The only report which has appeared regarding the general results of the field work is in three parts, unsigned, and in Spanish.[7] This report contains much information useful to the traveler in that desert country as well as details concerning the geology of localities not previously seen by trained observers.

4. Ings. Manuel Santillán and Tomás Barrera conducted explorations in northern Lower California in 1928 and published their results with a geological map in 1930.[8]

This is followed by reports by Hisakichi Hisazumi[9] and Dr. A.

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[6] A full list of the charts published by the Hydrographic Office of Western Mexico and Central America may be found in the publication: H. O. No. 84, Mexico and Central America Pilot (West Coast) sixth edition, Washington Government Printing Office, 1920, and the supplement to the same published in 1923. This publication also gives very valuable information on coastal depths, character of bottom sediments, place names and distances. See also Hanna, G. D. Proc. Calif. Acad. Science, ser. 4, vol. 15, 1926, p. 18, for a list of the most important sailing charts.

[7] [Part 1.] "Informe sobre la exploración Geológica de los Distritos de Altar, Hermosillo, Guaymas y Alamos, del Estado de Sonora, Mexico, por la Compañia Petrolera de Sonora, S. A."
Boletin del Petroleo, vol. 17, no. 5, May, 1924, pp. 362-379, 1 general map showing districts and boundary of concession, (pl. 1) and 24 plates of views, (pls. 2-25).

[Part 2.] "Informe sobre la exploración Geológica de la Baja California, por la Marland Oil Company of Mexico." Bol. d. Petrol. vol. 17, no. 6, June, 1924, pp. 417-453, 1 general map showing districts and boundaries of concession (pl. 1), and 40 plates of views, fauna, flora, etc., (pls. 4-10), 1 without number, 11, 12, 14-22, 26-46.

[Part 3.] "Informe sobre la exploración Geológica de la Baja California, por la 'Marland Oil Company of Mexico,' S. A." Bol. d. Petrol. vol. 18, no. 1, July, 1924, pp. 14-53, 1 geological map of entire peninsula and 16 plates of views, etc., (pls. 77-92).

[8] Manuel Santillán & Tomás Barrera, "Las possibilidades petroliferas en la costa occidental de la Baja California, entre los paralelos 30° y 32° de latitud norte." Anal. del Instituto d. Geologica d. Mexico, vol. 5, 1930, pp. 1-37, 1 geol. map (scale 1:2 M), and 12 photographic views.

[9] H. Hisazumi, "El Distrito sur de la Baja California." Anal. Inst. Geol. Mex. vol. 5, 1930, pp. 41-82 1 geol. map (scale 1:2 M), 7 cross sections of peninsula, 2 detailed sections, 2 block diagrams.

Pastor Giraud[10] on districts to the southward and in Sinaloa, which however, do not appear to mention any surface exposures of Cretaceous rocks.

5. An excellent map (scale 22.5 miles: 1 inch) for overland travel in Lower California was published in 1930 by the Automobile Club of Southern California. This shows the main route of travel from San Diego to Cape San Lucas and the topography is sketched in. The accompanying text gives much information of general interest.

6. Atlas Geografico de la Republica Mexicana, Secretaria de Agricultura y Fomento, Dirección de Estadios Geograficos y Climatologicos, Mexico D. F., 1919-1921; also in various editions up to 1929-1930. The first of the series (unnumbered) is a geological map of Mexico (scale 1:6.5 M) showing upper Cretaceous rather widely distributed in the Rosario coastal district and entirely across the peninsula from San Ignacio Lagoon to Santa Rosalia and northward along the Gulf coast. No. 3 is an excellent geographic map of Lower California, (scale 1:2 M), showing trails, habitations, water courses, etc.

7. Probably the best general account of Lower California with notes on previous scientific explorations and an extensive bibliography (444 titles) is that of Edward W. Nelson.[11] This, as well as many of the titles referred to in the bibliography, contains a great deal of information of interest to geologists and an excellent map.

Pre-Cretaceous Rocks

The existence of pre-Cretaceous rocks, crystalline and metamorphic, upon the peninsula is evident from the account given by Gabb, and also in the accounts of all subsequent writers.

Lindgren's description of the formations about Todos Santos Bay shows the later Cretaceous strata as resting upon older porphyritic rocks, which may well be pre-Cretaceous as well as pre-Chico in age.

Emmons and Merrill gave a general section across the peninsula near parallel 30° north. In this section the unaltered rocks, Cretaceous and later in age, occupy a zone less than one-fourth the width of the peninsula, while older rocks make up the larger part of the section. The granitic and schistose rocks reported by Gabb are presumably pre-Cretaceous, as is generally the case in California, and this may be true also of the volcanic and other classes from which the boulders of the "Mesa sandstone" reported by Gabb have been derived.

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[10] A. Pastor Giraud, "Informe geologico del ex-Distrito de San Ignacio, Estado de Sinaloa." Anal. Inst. Geol. Mex. vol. 5, 1930, pp. 85-113, 5 maps and sections. [This Ignacio should not be confused with San Ignacio, Lower California.]

[11] Edward W. Nelson, Lower California and its natural resources, Nat. Acad. Sci. Washington, Mem. vol. 16, pt. 1, 1922, pp. 1-194, 34 pls. of views, etc., 1 map (scale about 24 miles: 1 inch), showing roads, trails, waterholes, etc. and the general topography.

Granites appear at the southern end of the peninsula and extend northward from there beyond La Paz. Other areas are found intermittently along its eastern border as far north as the boundary. The sections given by Darton show granite and other crystalline rocks which are presumably pre-Cretaceous, along the eastern border near latitude 28° to 30° and farther.

On the western border of the peninsula granitic and other crystalline rocks were reported by Gabb in the Sierra Santa Clara, extending from San Sebastian Bay southeastward along the coast, which here also should be pre-Cretaceous in age, following the rule in California.

In two of Darton's sections near Magdalena Bay similar rocks are shown, and in many of the off-shore islands to the west later reports reveal rocks that by the same rule should be pre-Cretaceous. Such rocks are shown in published reports and photographs[12] as occurring on Cedros Island (pl. 11, fig. 1), and on neighboring islands, and at certain points on the mainland.

Cretaceous Deposits

San Fernando Formation. Lower Cretaceous rocks undoubtedly occur in Lower California, as they do in many other parts of the Pacific coast northward to Alaska, although they are here less well known paleontologically. On the map of the Marland Oil Company[13] there appear some large areas of rocks shown in the accompanying section as "metamorphic rocks," including limestones, slates, quartzites and intrusives, to which in the text (p. 49) are added conglomerates and sandstones. These appear to be the same rocks that were earlier described by Darton as "metamorphic Cretaceous," and which were later included by Santillán and Barrera[14] in their "Alisitos formation." As the account given by the geologists of the Marland Oil Company antedates that of the Mexican geologists, the name San Fernando formation seems to be appropriate, although the latter have given the only paleontological evidence as to the age of the group. In their discussion of the "Alisitos formation" they have given a considerable list of fossils, which, as determined by B. L. Clark, includes a number of forms generically named, which seem to indicate lower Cretaceous, and at least two species, *Amberlya dilleri* Stanton, and *Hypsipleura ? occidentalis* Stanton, well known in the Paskenta Group of the Shasta series in California. According to Darton the limestones are well filled with fossil oysters, which he regarded as of "upper Cretaceous age," although fossil oysters are not particularly diagnostic. The Paskenta group in California contains much limestone and also fossil oysters, both large and small.

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[12] G. D. Hanna, Pan-American Geologist, vol. 48, 1927, pp. 1-24.

[13] Carl Beal, Bol. del Petroleo, vol. 18, No. 1, 1924, opp. p. 52.

[14] Manuel Santillán and Tomás Barrera, An. del Inst. de Geol. vol. 5, 1930, pp. 9-14.

As far as can be learned from Darton's account his "metamorphic Cretaceous" differs in no respect from the San Fernando formation of Beal, or from the "Alisitos formation" of Santillán and Barrera.

Darton recognized only two principal series (groups), both of which he regarded as being of upper Cretaceous age, separated by an unconformity. The younger group he correlated with the "Chico" of California, whereas "the older series of unknown correlation" he described as "having been uplifted, flexed, and cut by large igneous masses before the youngest series, 'Chico', was deposited." The older series, which he did not find in immediate contact with the younger, he called the "pre-Chico," concerning which he says, in part (p. 726):

"These pre-Chico rocks consist of conglomerates, quartzites, tuffs, and agglomerates with large bodies of interbedded eruptive rocks. They are also cut by dikes and large stocks of igneous rocks of various kinds. In many localities the igneous rocks predominate over the sediments or pyroclastics, and in places there is much metamorphism. Unaltered, or but little altered sandstones and shales appear in places, notably near old San Domingo Mission, 25 miles north of San Quintin, where they contain large oyster shells, and in the Arroyo San José, 40 miles southeast of Santa Catarina. Limestone also occurs. It is conspicuous north and northeast of the ruins of Mission San Fernando, 30 miles due east of Rosario, ... "

From his statements and sectional diagrams there can hardly be a doubt that the "pre-Chico" group, which he also calls "metamorphic Cretaceous," is identical with the San Fernando formation of Beal, and the fact that it contains large oysters in no way conflicts with its determination as lower Cretaceous in age.

Chico Group. The first definite account of Cretaceous rocks on the peninsula was given by C. A. White[15] in 1885, in which he described the genus *Coralliochama* and a few other forms from the vicinity of Todos Santos Bay. This locality was later visited by Lindgren in January, 1888, and his account[16] adds to the information given by White.

Soon thereafter, H. W. Fairbanks made a further collection of fossils from this place, adding many species to the list then known,[17] and he reached the conclusion therefrom that these beds properly represented the Chico group of California, rather than an earlier unit, as was suggested by White. Since this visit by Fairbanks, large collections of fossils have been made at this locality for the California Academy of Sciences, and a long list of species is now known from there.

Although the list of species given by Fairbanks included some of Eocene age, 14 are clearly Cretaceous, and as here emended include the following:

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[15] C. A. White, U. S. Geol. Survey, Bull. No. 22, 1885, pp. 7-14.
[16] W. Lindgren, Proc. Calif. Acad. Sci., ser. 2, vol. 1, 1888, pp. 173-196.
[17] H. W. Fairbanks, Am. Jour. Sci., ser. 3, vol. 45, 1893, pp. 473-478.

Baculites chicoensis Trask
Coralliochama orcutti White
Glycymeris veatchi (Gabb)
Astarte mathewsoni Gabb
Aphrodina varians (Gabb)
Tellina ooides Gabb
Spisula ashburneri (Gabb)
Acila truncata Gabb
Leda translucida Gabb
"Ancyloceras" lineatus Gabb
Pugnellus sp.
Turritella chicoensis Gabb
Volutoderma sp.
Acteonina califia Stewart
Oligoptycha obliqua (Gabb)
Gyrodes expansa Gabb

Many species have since been obtained from this locality by the more recent collecting of C. H. Sternberg, L. G. Hertlein and E. K. Jordan. From these collections, as determined by the writers and Dr. Hertlein, the following may be added to the above list:

Baculites fairbanksi Anderson
Baculites occidentalis Meek
Tellina whitneyi Gabb
Tellina hoffmanni Gabb
Tellina mathewsoni Gabb
Tellina monilifera Gabb
Meekia navis Gabb
Modiolus cylindricus Gabb
Corbula traski Gabb
Lucina (?Myrtea) subcircularis Gabb
Anatina cf. affinis Whiteaves
Crassatellites tuscana (Gabb)
Venus steinyi Hertlein
Mactra gabbiana Anderson
Volutoderma gabbi White
Gyrodes californica Packard
Tornatella impressa Gabb
Tornatella normalis Cooper
Pugnellus rotundus Waring
"Ringicula" varia Gabb
Holzafilia sp.
Cirsostrema tenuisculptum Whiteaves
Trochus (Oxystele) euryostomus White
Acteon inornatus White
Lysis (Stomatia) intermedia (Cooper)
Ampullina sp.
Nerita sp.
Nuts of palms, etc.

According to Fairbanks, *Coralliochama* is found scattered through several hundred feet of strata. One bed four feet thick was composed almost entirely of these shells. In various localities in California this genus is found in beds that are regarded as low in the Chico group.[18] An inspection of the lists shows no other species that can be regarded as lower Chico, whereas, on the contrary, two-thirds of the number specifically named are found in middle Chico strata in the type districts of this group, and are probably not older than upper Turonian in age.

The Rosario formation. According to the account given by Beal,[19] a post-San Fernando emergence took place, which elevated the eastern part of the region, exposing this formation to erosion during the upper Cretaceous time, since in the sediments of the "Chico Cretaceous period (Rosario formation) there are found lenses of conglomerates which contain a large percentage of pebbles which seem to have come from this series" (p. 49).

[18] The name "Chico" is used in this paper in a broad sense with full realization that at a later date it may be necessary to restrict it somewhat or even to confine it to the strata exposed in Chico Creek, California and its equivalents elsewhere.

[19] Carl Beal, Bol. del Petroleo, vol. 18, 1924, p. 49.

As described by Santillán and Barrera the Rosaria formation was regarded as the equivalent of the Chico group, and from it they have supplied a considerable number of species supporting this view, which, according to B. L. Clark, include many only generically named, and the following diagnostic forms:

Baculites cf. fairbanksi Anderson
Schloenbachia sp.
Trigonia leana Gabb
Trigonia evansana Gabb
Pholadomya cf. breweri Gabb
Turritella chicoensis Gabb
Glycymeris veatchi (Gabb)
Inoceramus whitneyi Gabb
Ostrea parasitica (Gabb)

From Johnson's ranch, 15 miles south of Rosario, C. H. Sternberg obtained the following species, which for the most part seem to represent the same stratigraphic group:

Nemodon breweriana (Gabb)
Nemodon vancouverensis (Meek)
Crassatellites tuscana (Gabb)
Inoceramus whitneyi Gabb
Inoceramus cf. pembertoni Waring
Coralliochama orcutti White
Phacoides sp.
Gyrodes conradiana Gabb
Tessarolax incrustata A. and H., n. sp.
Turritella peninsularis A. and H., n. sp.
Dentalium (Entalis) whiteavesi A. and H.
Spondylus cf. rugosa Packard
Gryphaea sp.
Ostrea sp.

Catarina Formation. As viewed in the light of stratigraphic conditions found in the Coast Ranges of California within recent years it would appear that the conclusions reached by Emmons, Darton, and others regarding the upper Cretaceous sequence in Lower California will probably require revision. At least the upper part of the so-called "Chico formation," found about the mouth of Arroyo Santa Catarina, and in some localities farther north, is not different in age from an upper group of the Cretaceous found about Mount Diablo and in the Diablo Range in central California.

Attention has been called to this condition in a recent paper by J. A. Taff[20] in his discussion of the geology of Mount Diablo, California. He has found it necessary to revise the so-called "Panoche formation" of earlier writers, limiting it greatly, or in fact to a well defined upper part of the sequence to which the name had been applied. He says, in part (p. 1089):

"It is now demonstrated by areal field mapping that a well defined upper part of the Panoche formation with a conglomerate at its base containing Chico boulders, described by Anderson and Pack, is stratigraphically and unconformably above the type Chico formation and is the middle formation of the tripartite upper Cretaceous series of the Mount Diablo area."

Similar stratigraphic conditions extend along the east flank of the Diablo Range for a distance of more than 200 miles, and are recog-

[20] J. A. Taff, Bull. Geol. Soc. Am., vol. 46, 1935, pp. 1088-1089.

nizable throughout the Coast Ranges of California, and farther to the north and to the south.

It seems probable that the so-called "Chico formation" on the peninsula of Lower California should be restricted in like manner, and that the upper part should be given a distinctive name, for which the locality of Arroyo Catarina supplies an appropriate term. G. P. Merrill explored the peninsula as far south as about latitude 30° north in 1892, and his geological observations appeared in a joint account by himself and S. F. Emmons,[21] to which reference has already been made.

Type locality. These authors supplied a brief account of the strata exposed about the lower part of the Arroyo Santa Catarina and also a list of upper Cretaceous fossils from the area which were determined by T. W. Stanton, who regarded them as of "Chico" age, in accordance with the usage of that time. This paper marked an important advance by supplying definite information as to the extension of upper Cretaceous deposits on the Pacific coast of the peninsula so far to the south. The beds exposed there are described, in part, in the following language:

"Midway in the reentering curve between Canoas and Bluff points is the Playa Santa Catarina, where there is a gap a mile or two in width between the bluffs bordering the ocean, formed by a broad valley in which there are two modern stream beds draining the interior region. They are divided at the shore line by a flat-topped ridge of Chico beds, near the top of which is the remnant of an ancient stream bed whose bottom is about 100 feet above tide water, and which is filled by a conglomerate of large boulders and water worn pebbles of massive rocks. . . . . The lower beds exposed in the bluffs along the coast have a gentle inclination northward and southward from Sandstone point, three miles north of Playa Santa Catarina, where massive sandstones form a slightly projecting headland. In these sandstones carbonized plant remains, too indefinite for identification, were found, and in the cracks of the immediately overlying clays were traces of petroleum. From these beds and from the calcareous layers about 200 feet above were obtained the following forms as determined by Mr. T. W. Stanton:

Arca breweriana (Gabb)
Baculites chicoensis Trask
Tessarolax distorta Gabb
Inoceramus sp. indet.
Ammonites sp. indet.
Ostrea sp. indet."

Eocene fossils were also found in overlying beds.

In California the latest Cretaceous group, described by Taff as unconformably overlying the Chico proper, is best developed and most prominent in the Diablo Range southeast of San Francisco Bay, although it is traceable from there southward through various areas to San Diego. It is distinctly of Senonian age, and in its upper part carries a rich upper Senonian fauna. At its base it contains heavy beds of conglomerate, as described by Anderson and Pack,

[21] S. F. Emmons and G. P. Merrill, Bull. Geol. Soc. Am. vol. 5, 1894, pp. 489-514.

marking a conspicuous unconformity existing between it and the Chico group, as determined by characteristic Chico fossils found in its embedded boulders. This group of strata makes up a large upper part of the so-called "Panoche formation," and in some parts of the Diablo Range attains a thickness of over 20,000 feet.

Arroyo Santa Catarina. The uppermost beds about the mouth of the Arroyo Santa Catarina have the same stratigraphic position, character, and invertebrate faunas as those found in the Diablo Range in California. Within the last few years several accounts have been given, and in part published, as the results of explorations by, or for the California Academy of Sciences into the peninsula of Lower California, and by others, including Manuel Santillán and Tomás Barrera, and the accounts and collections made by Charles H. Sternberg, of San Diego. In these there is much information as to the occurrence and stratigraphic conditions of the Cretaceous rocks on the west coast of the peninsula as far south as latitude 28° north. These rocks appear to extend along the ocean side much beyond this latitude, and they might be found to extend inland even to the Gulf coast, as Gabb has indicated.

Many of the fossils obtained by Santillán and Barrera near Arroyo Santa Catarina were left at the University of California. A part of the collections made there by Sternberg, including all of the species obtained, was acquired by the California Academy of Sciences (Loc. 1431, C. A. S.). As both collections were made at nearly the same place, and represent the same horizon, they have been combined in the list of species given below. The Sternberg collection formed the basis of a brief note with a photographic plate, published by one of the present authors in 1928.[22] Unfortunately, in this note two names were used that now need alteration. The *Pachydiscus caterinae* of this note is here described as *Parapachydiscus catarinae*, and *Baculites ovatoides* is now believed to be *Baculites inornatus* Meek.

The beds themselves from which these fossils were obtained are those described by Emmons and Merrill, only a short distance east from the coast line of the reentrant between Canoas and Bluff points. They here constitute the type area of the *Catarina formation* described in the preceding pages. The beds extend rather widely from this point, northward beyond Rosario, and southward along the coast, at least as far as the mouth of Arroyo Grande, according to the areal mapping of Santillán and Barrera, although included by them as a part of the Rosario formation.

The following list of species is representative of the faunas of these beds, many of which are regarded as new (Loc. 1431):

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[22] F. M. Anderson, Pan-Amer. Geol., vol. 50, no. 4, 1928, pp. 283-284, pl. 9.

Parapachydiscus catarinae A. and H.
Parapachydiscus peninsularis A. and H.
Parapachydiscus ootacodensis (Stoliczka)
Nostoceras sternbergi A. and H.
"Hamites" vancouverensis Gabb
Baculites occidentalis Meek
Baculites vagina Forbes
Nautilus campbelli Meek
Nautilus cf. d'orbignyanus Forbes
"Nucula" solitaria Gabb
Pecten sp.
Oligoptycha obliqua (Gabb)
Gyrodes conradiana Gabb
Perissolax sp.
Turritella peninsularis A. and H.
Turritella parallela A. and H.
Volutoderma cf. magna Packard
Clisocolus cordatus Whiteaves
Glycymeris veatchi (Gabb)
Aphrodina major (Packard)
Acila truncata Gabb

Other localities. Darton's contribution supplies some data (p. 727), including lists of Cretaceous fossils. From a locality 15 miles north of Rosario he obtained a number of forms, determined by Dr. Stanton, as follows:

Rhynchonella sp.
Inoceramus whitneyi Gabb
Baculites chicoensis Trask
Baculites occidentalis Meek
Gyrodes sp.
Ostrea sp.
Nemodon vancouverensis (Meek)
Cinulia obliqua Gabb
Anchura sp.
Dentalium sp.

Although Darton assigned the horizon of these species to the "Chico" group of the California sequence, it seems to be advisable to reserve judgment concerning it until further information is available.

Midway between Todos Santos Bay and San Quintin, in the vicinity of San Antonio del Mar, Santillán and Barrera collected the following species which were left at the University of California (Loc. 647 U. C. Coll.):

Nemodon breweriana (Gabb)
Nemodon vancouverensis Meek
Crassatellites sp.
Corbis peninsularis A. and H.

Santillán and Barrera obtained at Punta Abaja (Rosario landing), the following species which were also left at the University of California:

Glycymeris veatchi (Gabb)
Opis rosarioensis A. and H.
Mytilus sp.

Other localities in the vicinity of San Antonio del Mar, intermediate between Todos Santos Bay and San Quintin, were visited by L. G. Hertlein and E. K. Jordan, who obtained there considerable collections of upper Cretaceous fossils. These collections contain many additional species, some new, but none older than those of the preceding lists. The results of these explorations will doubtless appear in due time, and need not be given here.

Darton has shown no Cretaceous rocks on the peninsula in any of his sections south of No. 5, which is just north of Arroyo Santa

Catarina. Beyond this point many of his sections do not reach the coast and are therefore incomplete.

G. D. Hanna has visited coastal areas farther south, and the following paragraphs are taken from his unpublished notes. He examined a portion of Cedros Island, which in some points attains an altitude of nearly 4,000 feet. In his account of the central part of the southern half of the island, he says, in part:[23]

"This portion of the island consists of thin-bedded and contorted cherts, slates and metamorphic rocks (pl. 11, fig. 1), partly surrounded on the north and east by Cretaceous shales and sandstones. Two extensive areas of Cretaceous exist on the island. One is near its south end in the canyon leading back from the Bernstein Abalone packing plant. About a mile inland there is a series of bald hills composed of thinly bedded, muddy shales. These weather readily into conspicuous rounded masses; on some of the slopes of these an occasional harder, iron-stained layer projects slightly above the general surface. The dip is constantly to the west at an angle of about 30° on the average, but in some cases it was noted to be as high as 45°. High mountains of schist and chert limit these deposits on the north and west, and eastwardly they are covered by Miocene and Pliocene. In one of the exposures on the north side of Bernstein Canyon a considerable number of poorly preserved fossils was found. These consist of *Ammonites*, and *Inoceramus*, some peculiar plant remains, and sundry nondescript Foraminifera. The assemblage is sufficient to determine the age as Cretaceous. . . . The other exposure of the same character of material is found some nine miles north of the one just described, and on the north side of the large central valley locally known as 'Grand Canyon,' but more correctly called Dearing Valley, after Veatch. The shales here reach an altitude of 2000 feet and probably more. The dip is again to the westward, the angle being in general about 30°. No fossils were found, but no part of the deposits have been searched carefully. Where the shales reach the coast there is a fringe of Pliocene about the base of the cliffs. . . . "

An examination of the fossils referred to above proves the Ammonite to be a species of *Phylloceras*, in size and sculpture very similar to *Phylloceras velledae* Michelin, although it might be an older form. The fragment of *Inoceramus* is not specifically determinable. However, in any case the Cretaceous beds outcropping here should be older than the Catarina formation, and they may well be lower Chico (Cenomanian or older), and such determination would harmonize with the structure of the region.

Although mountains of schist and chert are mentioned in the note, no metamorphism of the Cretaceous beds is indicated, and no eruptive dikes were seen cutting any of them, as was the case with the "metamorphic Cretaceous" described by Gabb, and later confirmed by Darton and by Beal. This fact might perhaps throw additional light upon the supposed age of the San Fernando formation, believed to be the equivalent of the "metamorphic Cretaceous."

North and south of Bernstein Canyon some volcanic rocks, granites, or gneisses, and other classes of pre-Cretaceous formations were noted, but the examination was not sufficiently thorough for any final conclusions.

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[23] G. D. Hanna, Manuscript notes.

The San Benito Islands, to the west of Cedros Island, are largely composed of cherts, supposed to be of Mesozoic age.

Natividad Island (pl. 11, fig. 2) lies between Cedros Island and the mainland to the south, concerning which we have the following note:

"This island lies about eight miles south of Cedros, and is almost entirely composed of hard muddy shales, sandstones and conglomerates. We landed at the south end and found nothing else to the north for a distance of about four miles, or almost the length of the island. The shore lines are mostly bold, due to the relative ease with which the rocks are carved by the sea. The attitude of the beds is so inconsistent in short distances that no certain view could be formed as to structures. The strata dip variously from 0° to 75°, and an equal discordance in strike leads to the supposition that the island is on, or very near a fault zone of major proportions. . . . "

This island forms a connecting link between the older rocks of Cedros Island and the granitic and metamorphic rocks of the Sierra Santa Clara, referred to by Gabb.

As to what formations cover the flanks of the Sierra Santa Clara we have little positive evidence. To the east are the "Mesa sandstones" described by Gabb; to the west the rocks resemble lithologically the Cretaceous strata on Cedros Island. Crystalline rocks seem to form the core of the range, and these are flanked along the southwest by two unconformable Cretaceous (?) groups. Referring to the formations found along the coast of the mainland, we have the following field notes (G. D. H.):

"Southeast of Turtle Bay about two miles, and partly beneath conspicuous hills of Pliocene and Miocene, there are some very prominent exposures of conglomerate. These dip to the southwest at about 30°, and strike northwest to southeast. The boulders are well rounded, the largest noted being about five inches in diameter. A great many of them are of quartzite. . . .

"It seemed at the time of our visit that on projecting the strike to the northwest the same beds should occur in the prominent range of hills beyond Turtle Bay, but this could not be investigated at the time. However, on the north side of the Bay, and east of the range of hills mentioned, there is a very extensive outcrop of hard sandstones and muddy shales. This exposure is on the bay shore and was carefully examined; the strata were estimated to have a thickness of at least 10,000 feet. The dip is constantly to the south, 80° west, and varies from 45° to nearly vertical, but no evidence of unconformity was seen. No fossils were found in these beds, but from their lithologic similarity to the rocks on Cedros Island, which contained fossils, they are believed to be Cretaceous."

The field notes, from which these quotations are extracted (G. D. H.), continue to the south, and include the following:

"The land surface in the immediate vicinity of Abreojos Point has been planed off and projects only a few feet above the sea. About 1000 feet of hard gray and brown sandstones and shales outcrop on the south side of the point. The strata strike northwest and southeast, and have a dip of 15° to the southwest. Immediately above, there are about 1500 feet of very hard, well cemented conglomerate with boulders up to eight inches in diameter. A slightly different dip and strike indicates the presence of an unconformity between the lower beds and this conglomerate.

. . . No fossils were found in these hard strata, but they were supposed to be Cretaceous, on account of their resemblance to the strata of that age on Cedros Island. . . . "

Carrying these observations even farther south along the Pacific coast of the peninsula, we have the following notes on the geology of Margarita Island, on the west side of Magdalena Bay:

"Santa Margarita is a high rugged island, 20 miles long and four wide, forming the outer barrier of the southern end of Magdalena Bay. It consists of two parts, connected in the center by a low isthmus. The high northern and southern parts are not well known geologically, but the meager evidence available indicates that they are composed of metamorphic and igneous rocks almost entirely. Near the center of the isthmus there is a conspicuous outcrop of thinly bedded sandstones (pl. 11, fig. 3) dipping westerly at about 80°. No fossils were found in them, but the amount of induration indicates that they are older than the Tertiary. . . . "

The photograph supports the belief that these beds are also Cretaceous, and they rest against the older metamorphic and igneous rocks beneath, that is, to the east, as is the case on the peninsula; more than this can not be said.

It would appear from the foregoing accounts that as a general condition of structure, as well as of composition, the peninsula of Lower California is not essentially different from the coastal parts of southern and central California. In its wider portions it appears to be outlined on both borders by axes of older crystalline or metamorphic rocks, between which rest gently dipping, or often much disturbed beds of later Cretaceous and Tertiary rocks, which in general occupy a synclinal trough. Some of the sections, as that to the south of Vizcaino Bay, show a distinct axis on the west border (Sierra Santa Clara) of which Cedros Island is a prolongation, recalling the structural conditions found in the Santa Maria and Salinas valleys of California.

Stratigraphic Relations

The stratigraphic relations of the beds found in the several localities referred to in the foregoing text are not yet fully known, since only in part is there any indication found in the several accounts. The relations are, therefore, known only from the paleontological evidence that has been recorded, and this is not wholly satisfactory, largely from lack of sufficient material.

The list of invertebrate fossils obtained from Punta Banda, which at present is the most complete, contains no species that can be taken as representing strata older than middle Chico (lower Turonian), and most of the forms have been described from higher horizons. On the other hand, none of the species indicate a position as high in the column as that of the Catarina formation. *Coralliochama orcutti* White, of which this is the type locality, has sometimes been regarded as evidence of a lower Chico horizon, but this can hardly be accepted.

Its fossil associates at this locality do not support this view. According to Fairbanks[24] it occurs at Point Loma and at La Jolla, San Diego County, in beds that seem to be Senonian, rather than Turonian in age. This species is not identical with that found in lower Chico beds (Cenomanian, or older) occurring in the Cottonwood district, Shasta County, associated with abundant cephalopod forms.

The stratigraphic position of some of the beds about Rosario, as indicated by the fossils, is not higher than that at Punta Banda, and it may be lower. That higher beds are found in this vicinity seems to be probable as judged from the few species found near Rosario landing, and also at other points.

It has been shown that the strata constituting the Catarina formation are of upper Senonian age, and therefore higher than any of the beds at Punta Banda, or even at Rosario, from which the Rosario formation takes its name.

The Rosario formation, as indicated by the fossils collected by Santillán and Barrera, is not younger than Turonian. Its stratigraphic relations to the Catarina formation is inferred from its age, but has not been determined stratigraphically.

The stratigraphic relation of the Rosario formation to the underlying San Fernando formation appears to be one of unconformity, as stated and illustrated by Darton, and as seems to have been recognized by Beal and others. Darton named no fossil species as representing the older series (San Fernando), but reports limestones in it "filled with fossil oysters," which he took to be upper Cretaceous in age. Much limestone and various species of fossil oysters have also been found in the lowest group of the lower Cretaceous in California, and in Oregon, upon which Chico beds rest unconformably. Until the lower "series" described by Darton has been proved to be younger, it may be well to regard the same as probably belonging to the Shasta series. If the "older series" described by Darton should ultimately be proved to be of upper Cretaceous age, which seems unlikely, the unconformity might also be shown to be equivalent to that between the Chico group and the Panoche formation in California.

Correlation

The Cretaceous deposits found in Lower California have been correctly regarded as geographical extensions of the contemporary deposits in California, and as such are capable of direct correlation with them. In so far as any faunal evidence has been recorded, or obtained, these deposits on the peninsula show the same stratigraphic succession as those found in the Diablo Range of central California. The oldest beds appear to belong low in the Cretaceous section, and have been correlated with the Paskenta group of the Shasta series.

[24] H. W. Fairbanks, Amer. Jour. Sci., vol. 45, 1893, pp. 473-478.

The upper Cretaceous deposits on the peninsula correspond in part to the Chico group in the Diablo Range, and in part to the later portion of the Panoche formation, as restricted by J. A. Taff, which lies unconformably upon Chico deposits in many parts of California, and farther to the north.

Equivalents of one or the other part of this upper Cretaceous sequence are spread along the Pacific coast through many degrees of latitude, namely along the coasts of Alaska, British Columbia, Washington, Oregon, northern and central California, Lower California, and to southern Chile, the Straits of Magellan and farther.

As known in California the upper Cretaceous deposits divide themselves into two distinct groups, lower and upper, and in part into smaller divisions. The older, or Chico group of the upper Cretaceous, is restricted in its stratigraphic span to that of its type districts, and geographically is confined to relatively smaller areas than the later group, due partly to overlaps. The later group is much thicker, and has a wider geographical range.

In California the Chico group has a chronological span from late Albian to late Turonian, whereas the beds so far found on the peninsula contain neither Albian nor Cenomanian strata. The lowest beds that have been regarded as upper Cretaceous, namely, those at Punta Banda, can hardly be older than middle Turonian. The horizons represented by the collections made between Punta Banda and Rosario, may be later, and may possibly be as late as lower Senonian, although no Ammonites have yet been found in them that would serve for determining this point.

The Catarina formation on the peninsula is not known to have the stratigraphic span of the Panoche formation in the Diablo Range, and may be equivalent to only its upper portion. Its known fauna is upper Senonian in age, but it may later be found to extend lower. The formation is not known to be unconformable upon the Chico group, or upon the beds that have been referred thereto, although this may later be shown to be the case.

The rich Senonian faunas in the Diablo Range can not be described here, although reference to them can hardly be avoided. They consist mainly of many genera and species of cephalopods as well as pelecypods and gastropods. Their horizon lies some 600 to 1000 feet below the contact of the Panoche formation, and the overlying Moreno formation, also Cretaceous. Similar beds are found in northern California and in Oregon. Other Pacific coast localities farther to the north are known in Vancouver Island and in the Straits of Georgia on some of its islands. Farther to the north they may occur about the Queen Charlotte Islands, or on the Alaskan coast, since they are found also in Japan.

In the opposite direction the upper Cretaceous beds known on the Quiriquina Island, southern Chile, have been classed by Steinmann[25] as of Senonian age. In fact, this author has correlated them

[25] G. Steinmann, N. Jahrb. f. Min. Geol., etc., Beil. Bd. 10, 1895, pp. 29-30.

with the Arrialoor (Valudayur) group in southern India, which are said to be unconformable upon older Cretaceous beds in that region. According to F. Kossmat,[26] these Arrialoor beds are of Senonian age, as shown by many cephalopod forms. According to Steinmann the equivalence of the Quiriquina beds to the Arrialoor is shown by the occurrence in both of many common species, and also by many analogues, all of which support this correlation.

In western Europe the nearest faunal equivalents of those found in the Catarina formation are in the upper Senonian (Campanian), and the same is probably true of the rich faunas of upper Panoche beds in the Diablo range. This correlation is supported by the presence in all of these Pacific coast beds of large forms of *Parapachydiscus*, by the gerontic forms, "*Hamites*" and *Nostoceras*, and by species of *Baculites*, including one very near to *Baculites vagina* Forbes, and also one near to *Baculites anceps* Lamarck.

Kilian and Reboul[27] have described a considerable fauna of upper Cretaceous age from Snow Hill and Seymour Island, on the borders of Antarctica, but without giving complete stratigraphic information. The lists of species contained in their account indicate strata ranging from Cenomanian to upper Senonian, or higher.

The more complete faunas described from this region are those of upper Turonian and Senonian (Campanian), or higher. These authors have compared the faunas of Snow Hill and Seymour Island with similar faunas on Vancouver Island, California, Chile, Patagonia, Natal, Pondoland, Madagascar, and other places. In their correlations (pp. 59-60) they say, in part:

> "It results from these comparisons that the Cretaceous formations of Snow Hill and Seymour Island correspond, on the whole, in their faunal characters to the Senonian (Santonian, Maestrichtian) of the Trichinopoly district in India, with which they may be synchronous."

The great majority of forms studied indicate a horizon of upper Cretaceous near to upper Senonian (Aturian-Maestrichtian) as is shown by the presence of such characteristic forms as *Phylloceras ramosum* Meek, *Pseudophyllites indra* Forbes, *Pachydiscus gollevillensis* d'Orbigny, *Anisoceras notabile* Whiteaves. In this correlation the species most relied upon are such as chiefly characterize the Catarina formation and their equivalents in the upper part of the Panoche formation in central California.

The complete evidence upon which these correlations rest cannot be given here, but some of the more common forms found in the Catarina formation are included in the descriptions of species in the latter part of this paper. On the following page is given a tentative correlation table of formations occurring on the peninsula with those of California and other regions.

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[26] F. Kossmat, Jahrb. d. K. K. Geol. Reichs. 1894, Bd. 14, p. 459.

[27] W. Kilian and P. Reboul, Wiss. Ergeb. der Schw. Sudpol. Exped. 1901-1903, Bd. 3, Lief. 6.

		Diablo Range		*Santa Ana Mountains*	*San Diego*	*Lower California*	*Southern India*
Maestrichtian							
Senonian	Campanian	Panoche formation	Rich Cephalopod fauna	Cephalopod fauna	Pt. Loma-Cephalopod fauna	Catarina formation Cephalopod fauna	Arrialoor (Valudayur)
	Santonian		Scanty fauna			Johnson's ranch	
	Coniacian		Conglomerate Unconformity				
Turonian		Chico group	Scanty fauna	Lower fossil beds		Punta Banda beds	Trichinopoly beds
Cenomanian			Type Chico Fauna				
			Lower Chico fauna			Cedros Island beds?	Ootatoor beds
Albian			Conglomerate Unconformity				

Description of Species

In the following notes on the upper Cretaceous Mollusca of Lower California, various new species have been described briefly, with some references to their relationships elsewhere, as far as known. A few not new to science are also considered, with a view to ascertain the correct correlation of the strata discussed in the preceding pages. No attempt is made to give exhaustive references to the citations of other writers, which would prolong the present paper unduly, although enough is included to form a sort of key to the scattered literature of the particular species considered.

In some cases of synonomy corrections have been made, although with feelings of regret. It is possible that some of the names of doubtfully identified species will later need revision, and it is hoped that subsequent collections will considerably enlarge the lists herein contained, as well as extend the information as to the horizons of the Cretaceous here represented, and of their stratigraphic relations above and below.

Unless otherwise specified, the species contained in the following paragraphs, and especially the type examples, are to be found in the collections of the California Academy of Sciences and of the University of California.

Parapachydiscus catarinae Anderson and Hanna, new species

Plate 1, figure 1; plate 2, figure 1; plate 3, figures 1–3

Pachydiscus caterinae Hanna and Anderson, Pan-Amer. Geol., vol. 50, no. 4, 1928, p. 238, pl. 9 (without description).

Shell very large, smooth, flattened on the sides, although moderately inflated; shell almost without surface ornamentation, or showing almost obsolete ribs, or undulations, which curve slightly forward; diameter of holotype, without body-chamber, 19.8 inches (50.3 cm.); height of whorl, from umbilicus to periphery at the last septum, 8.52 inches (21.6 cm.); height of preceding whorl, 3.42 inches (86.8 mm.); incremental ratio in last whorl, 2.49; ratio of umbilicus to last whorl, .200-.215, increasing gradually with growth of shell; ratio of involution to height of whorl, nearly .31; ratio of width of whorl to height, .79; periphery of septate portion of whorl, 53 inches (134.6 cm.).

Holotype: No. 4245 Mus. Calif. Acad. Sci. Paleo. was obtained from Loc. 1431 (C. A. S.), near **Santa Catarina Landing, Lower California;** paratypes, Nos. 4246 and 4247 are from the same locality.

This is the largest species of cephalopod yet seen in the Cretaceous of the Pacific coast. If the body-chamber occupied only one-quarter of a whorl the diameter would be 26 inches, or if it extended only 24 inches from the last septum, the diameter would be 28 inches.

The species is clearly a member of the group of *P. ootacodensis* (Stoliczka), which probably also includes *P. neevesi* Whiteaves, al-

though the sutural characters of the latter are not known. Whiteaves believed them to be similar to those of *P. ootacodensis* (Stol.). Steinmann also compares *P. quiriquinae* Phil. with the Indian form, although its umbilical border is more rounded, and the section of the whorl is generally more inflated than in either *P. neevesi* or *P. catarinae*.

Parapachydiscus catarinae is also found in the uppermost beds of the Panoche formation in the Diablo Range, central California, and apparently in the same upper Senonian horizon.

Parapachydiscus ootacodensis (Stoliczka)

Plate 6, figures 1, 2

Ammonites ootacodensis Stoliczka, Cret. Ceph. S. India, vol. 1, p. 109, pl. 54, figs. 3, 4; pl. 56; (not pl. 57, vide Kossmat).

Pachydiscus ootacodensis, Kossmat, Beitr. z. Pal. Oest. Ung. u. des Orient. 1897, p. 98, pls. 16, 17, figs. 1a, 1b, etc. . . . Whiteaves, Mes. Foss. vol. 1, pt. 5, p. 340, pl. 46, fig. 1; Hornby Island, British Columbia.

Whiteaves figured and described this species after having submitted his specimens to Kossmat for identification. He included Kossmat's notes in his discussion, which aid greatly in the recognition of our example from Lower California. The specimen from Catarina landing is 3 inches (76.2 mm.) in greatest diameter, the greatest thickness being 1.3 inches (33 mm.); it is septate throughout. The greatest umbilical diameter is about 0.75 inch (1.9 cm.), and the umbilical ratio, 0.254. The umbilical walls are abrupt within, not vertical, and rounded on the borders. The ribs are simple, low, rounded, spaced about one centimeter apart on the periphery, of which there are 24 on the complete whorl, curving slightly forward in the outer zone, and crossing the abdomen, which is somewhat narrowed.

Plesiotype: No. 4251 Mus. Calif. Acad. Sci. Paleo. from Loc. 1431 (C. A. S.) near **Santa Catarina Landing, Lower California.**

A careful comparison of our specimen with the figures given by Stoliczka and Whiteaves, aided by Kossmat's notes, makes the determination of the species appear quite satisfactory.

Parapachydiscus peninsularis Anderson and Hanna, new species

Plate 4, figure 1; plate 5, figures 1, 2; plate 6, figures 3, 4; plate 7, figure 5; text-figure 1.

Shell large, inflated, costate, moderately involute; section of whorl nearly semicircular in young stages (ratio 1:1.5); at a diameter of 3.25 inches (9 cm.) the ratio of height to width is 1.272; with increasing growth the ratio becomes smaller; at 14 inches (35.5 cm.) the ratio is reduced to 1:0.928; ribs about 56 in number, in two ranks; in shells 6 inches (15 cm.) in diameter, the ribs alternate; the stronger ribs slightly bullate on the umbilical border; ribs scarcely extending across the ventral zone; secondary ribs not bullate, more numerous than the primary, becoming re-

duced near the umbilical and ventral borders; walls of umbilicus abrupt in young shells, more rounded in larger individuals; ratio of umbilicus to diameter, varying from .226 in young stages to .222 in shells 14 inches in diameter.

Fig. 1. Septum of *Parapachydiscus peninsularis* Anderson & Hanna, new species. Drawn from Paratype, No. 4257 (C. A. S. Paleo. type coll.).

Holotype: No. 4248 Mus. Calif. Acad. Sci. Paleo. from Loc. 1431 (C. A. S.) near **Santa Catarina Landing, Lower California;** paratypes, Nos. 4249, 4250, 4253, 4257, same collection and locality.

In surface features this species greatly resembles *P. deccanensis* Stoliczka (in part), from the Arrialoor group of India. It appears, however, to belong to the group of *P. colligatus* Binckhorst, from the Senonian beds of Limbourg. The sutures (fig. 1) are not unlike those of *P. arrialoorensis* Stoliczka of southern India.

The species has been found in the upper Cretaceous beds of the Santa Ana Mountains, Orange County, together with a near relative, and in beds of the same age, upper part of the Panoche formation, in the Diablo Range near Coalinga, California.

A nearly related species is in the collections of Stanford University from the Santa Ana Mountains, and also a large fragment of *P. peninsularis* from near Coalinga, Fresno County. The species is associated with *P. catarinae*, and with "*Desmoceras*" cf. *damesi* Jimbo near Coalinga, in the upper beds of the Panoche formation.

Nostoceras Hyatt

Genotype: *Nostoceras stantoni* Hyatt, Proc. Am. Phil. Soc., vol. 32, 1893, pp. 569-571; upper Cretaceous, Texas.

Nostoceras sternbergi Anderson and Hanna, new species

Plate 7, figure 1; text figure 2

Shell rather large, the holotype consisting of the retroversal, body chamber of the shell, measuring 4.3 inches (10.9 cm.) in length, cylindrical in section, irregularly costate, irregularly nodose; last septum showing at the proximal end of the longer limb; costae of various sorts; some on the smaller limb are oblique, simple, narrow and sharp ridges which run continuously around whorl without dividing, separated by wider concave interspaces; others near the middle of this limb bifurcate on either side of the whorl and continue as the former; others beyond the middle of the limb branch into three divisions which cross the venter and join on the opposite side; others near the bend of the hook branch into five or six smaller costae, cross the venter and reunite again as the former; on the distal end of the body chamber the ribs are heavy, coarse and irregular, some dividing, others simple; nodes sharp, narrow and elongated, irregularly, distributed along the ventral borders, mostly reduced in size, or almost obsolete. An oblique constriction midway of the proximal limb extends continuously around the whorl.

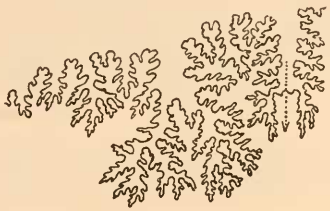

Fig. 2. Septum of *Nostoceras sternbergi* Anderson & Hanna, new species. Drawn from Paratype, No. 4255 (C. A. S. Paleo. type coll.).

Holotype: No. 4254 Mus. Calif. Acad. Sci. Paleo. from Loc. 1431 (C. A. S.) near the mouth of **Arroyo Santa Catarina, Lower California;** paratype, No. 4255, same collection and locality.

Whiteaves figured and described a similar species under the name "*Anisoceras cooperi*" (Gabb), from Hornby Island, and it appears also to be irregularly costate, although more nodose than the species here described. He believed his species to be identical with Gabb's, and to the present writers this appears to be possible. An example of our species, retained by C. H. Sternberg, has somewhat more numerous nodes on the peripheral borders than are present on the holotype, although in other features the two are very similar. In all specimens of the species thus far seen the retroversal portion forms a loop approximately in one plane, turning downward at the septate end as if to connect with a sinstral helicoid spire, the surface features of which are at present not known. The species is named in honor of its discoverer, Charles H. Sternberg, the veteran collector of many vertebrate and other fossils throughout the western states.

At its type locality the species was associated with "*Hamites*" *vancouverensis* Gabb, *Parapachydiscus catarinae*, *P. peninsularis*, *P. ootacodensis* and many other species given in the preceding list.

A very similar, if not identical form was found at La Jolla, San Diego County, which is now in the Museum of Scripps Institution. It was loaned for study to the California Academy of Sciences by Dr. T. W. Vaughan, and was compared with the holotype.

"Hamites" vancouverensis Gabb

Plate 7, figures 2, 3, 4; plate 8, figure 5

Hamites vancouverensis Gabb, Geol. Surv. Calif. Pal., vol. 1, 1864, p. 70, pl. 13, fig. 18; Upper Cretaceous, Comox, Vancouver Island.

Hamites (*? Ancyloceras*) *vancouverensis* Gabb, Geol. Surv. Calif. Pal., vol. 2, 1869, p. 212; Chico group, Vancouver Island.

Hamites vancouverensis Gabb, Whiteaves, Mes. Foss., vol. 1, pt. 2, 1879, p. 112; associated with *Pachydiscus newberryanus* Meek.

Anisoceras cooperi (Gabb), Whiteaves, (in part), Mes. Foss., vol. 1, pt. 5, 1903, p. 336 (not pl. 43, fig. 1).

Although Whiteaves was inclined to unite *H. vancouverensis* and "*Anisoceras*" *cooperi* (Gabb) as being synonymous, his identification of the former was not positive. It seems likely that the form from Hornby Island (pl. 43, fig. 1) is really Gabb's species "*Amm.*" *cooperi*, although there are some differences apparent in the figures. In the specimens of *H. vancouverensis* Gabb from Catarina Landing, the ribs cross the venter (dorsum of Gabb and Meek), which is slightly flattened, and form on either side of the ventral zone, rows of depressed nodes which become more prominent on the distal limb of the body chamber, the ribs becoming here more widely spaced and at the same time stronger. The shell is sharply bent, forming a closely folded hook, the space between the limbs being less than half the width of the proximal limb. The septum is unknown.

In merging this species with *Emperoceras* (?) *cooperi* (Gabb), Whiteaves overlooked the fact that according to the description, *H. vancouverensis* has sharp and simple ribs crossing the venter, while in his own figure (pl. 43, fig. 1) the ribs divide on the side into two or more branches.

Three fragmentary specimens of *H. vancouverensis* were obtained by Srs. Barrera and Santillán near Santa Catarina Landing, and are in the collections of the University of California. A similar form, much compressed by rock pressure, has been loaned to the California Academy of Sciences by Dr. T. W. Vaughan for study; it was obtained at La Jolla, California.

Similar species are not uncommon in the upper Cretaceous deposits of California, although most of the examples are fragmentary.

Baculites occidentalis Meek

Plate 8, figures 3, 4

Baculites occidentalis MEEK, Proc. Acad. Nat. Sci. Phila., vol. 13, 1861, p. 316.—MEEK, Bull. U. S. Geog. & Geol. Survey, Terr., vol. 2, no. 4, 1876, p. 366, pl. 4, figs. 1, 1*a*, 1*b*; Sucia Island, Straits of Georgia.—WHITEAVES, Mes. Foss., vol. 1, pt. 2, 1879, p. 115; pt. 5, 1903, p. 339; (*B. chicoensis* Whit. in part).

Meek's emended description of this species (1876, p. 366) reads:

"Shell attaining a medium size, very gradually tapering; section subtrigonal, excepting the smaller end, where it is more nearly ovate; antisiphonal, or broader surface flattened so as to give its lateral margins a more or less angular appearance; sides converging with slightly convex outlines from these angles to the narrowly rounded or obtusely angular siphonal margin; aperture subtrigonal, etc. . . . "

Meek gives a distinctive septum for this species (pl. 4, fig. 1b) which should leave no doubt as to its validity as a well marked upper Cretaceous, Pacific Coast form. It has not yet been positively identified in the lower or middle Chico beds of California, but occurs plentifully in the upper beds of the Diablo Group, and at Santa Catarina Landing, Lower California, in the same horizon.

Baculites inornatus Meek

Plate 8, figures 1, 2

Baculites inornatus MEEK, Proc. Acad. Nat. Sci., Phila., vol. 13, 1861, p. 316; Sucia Island, Straits of Georgia.—GABB, Geol. Surv. Calif., Pal., vol. 2, 1869, p. 214; locality as above.

Baculites chicoensis, MEEK (in part, not Trask), Bull. U. S. Geog. & Geol. Survey, Terr., vol. 2, no. 4, 1876, p. 364, pl. 4, figs. 2, 2*a*, 2*b*, 2*c;* locality as above.

Baculites ovatoides HANNA and ANDERSON, Pan-Amer. Geol., vol. 50, no. 4, 1928, p. 283, pl. 9; nomen nudum.

It appears that Gabb did not recognize either of Meek's two West Coast species, *Baculites occidentalis* and *B. inornatus*, but figured a distinct form from Sucia Island, calling it "*B. occidentalis* Meek." It was perhaps this error that induced Meek to doubt the validity of either, supposing them both to be possibly varieties of *B. chicoensis* Trask, but this view appears to be untenable. In fact it is not difficult in most well preserved specimens to distinguish all three forms, although they often occur together. In the collections of the California Academy of Sciences there are numerous examples of *B. inornatus* from Sucia Island, showing well preserved suture lines. They differ considerably from *B. chicoensis*, of which Gabb has furnished a good illustration. As observed by Meek, *B. inornatus* is larger than *B. chicoensis*, has a distinctive suture and is more oval in section (not ovate) than *B. occidentalis*, and its sutural characters, as shown by his figures differ from all the others.

Baculites inornatus occurs in many places in California, and in Lower California, in upper beds of the Panoche formation, often associated with *B. occidentalis*.

Plesiotype: No. 4258 Mus. Calif. Acad. Sci. Paleo. is from Loc. 1431 (C. A. S.) Santa Catarina Landing, Lower California.

Nautilus campbelli Meek

Nautilus campbelli Meek, Proc. Acad. Nat. Sci. Phila., vol. 13, 1861, p. 318;—Meek, Bull. U. S. Geog. & Geol. Survey, Terr., vol. 2, 1876, p. 373, pl. 6, figs. 2, 2*a*; Comox, Vancouver Island.—Whiteaves, Mes. Foss., vol. 1, pt. 2, 1879, p. 99, pl. 11, (?) figs. 2, 2*a*, 2*b*; pt. 5, 1903, p. 327; locality as above.

This species has been obtained from the upper Cretaceous near the mouth of Arroyo Santa Catarina, Lower California. It appears to be very nearly related to *N. blanfordianus* Kilian & Reboul from the Island of Seymour and Snow Hill, Antarctica. According to these authors this latter species is identical with *N. bouchardianus* d'Orb., as identified by Blanford and Stoliczka, and probably also with *N. subplicatus* Philippi (in Steinmann) from Quiriquina Island on the Chilean Coast.

Two good specimens are in the collections of the California Academy of Sciences from Loc. 1431 (C. A. S.), near Santa Catarina Landing.

Nautilus d'orbignyanus E. Forbes

Nautilus d'orbignyanus E. Forbes (in Darwin), Geol. Obs. in S. America, 1851, p. 265, pl. 5, fig. 1.—Steinmann, N. Jahrb. f. Min. Geol., etc., Beil. Bd. 10, 1895, p. 64; Island of Quiriquina, Coast of Chile.

This species is apparently abundant at various places in the upper Cretaceous deposits of Lower California, and has been obtained with the preceding near the mouth of Arroyo Santa Catarina, and at other points farther north on the peninsula. It has also been identified among the fossils collected from the Panoche formation of western Fresno County, California. Good examples are in the collections of the California Academy of Sciences from Loc. 1431 (C. A. S.) Santa Catarina Landing.

Turritella peninsularis Anderson and Hanna, new species

Plate 10, figure 5

Shell of medium size, robust; whorls subangular; sutural grooves impressed, deep and broad; sides of whorls flattened or slightly concave; surface almost smooth on holotype, ornamented by faint revolving threads crossed by sinuous lines of growth; aperture sub-quadrate; spire high, tapering gradually to apex; whorls rounded on shoulders.

Holotype: No. 4709 Mus. Calif. Acad. Sci. Paleo. was obtained at Loc. 1430 (C. A. S.) at **Johnson's ranch, 15 miles south of Rosario, Lower California,** where it was found associated with other species given in a foregoing list.

In size and form, as also in ornamentation, this species greatly resembles *T. pachecoensis* Stanton, an Eocene (Martinez) form from central California, and indeed it is not readily distinguished from it. Our species occurring on the peninsula of Lower California associated with many well known Cretaceous species, requires a distinctive name, and for this reason the above is proposed for it.

Turritella parallela Anderson and Hanna, new species

Plate 9, figs. 1, 2, 3

(?) *Turritella seriatim-granulata* GABB (not ROEMER), Geol. Surv. Calif. Pal., vol. 1, 1864, p. 132, pl. 20, figs. 88; Tuscan Springs, Tehama County, California; vol. 2, 1869, pp. 227, 263; loc. as above.—STEWART, Proc. Acad. Nat. Sci. Philadelphia, vol. 78, 1926, p. 348, pl. 21, fig. 2; (one of Gabb's specimens).

Gabb believed he had recognized Roemer's Texas species in the Chico beds of California, and doubtfully referred to others as possible synonyms. A comparison of his figures with those referred to and a study of his description do not support the identification, although there is a general resemblance in the ornamentation. The much narrower apical angle and the greater elongation of the form here considered, and of all California species thus far seen, remove them from any suspicion of identity with the Texas forms. In the holotype here used as the basis of comparison the shell is very slender, elongated, tapering very gradually or almost imperceptibly; sides of whorls flat, or only slightly convex; sutures slightly impressed; whorls banded with four or five beaded threads, the super-sutural one being heavier and smoother than the others; above this the three or four on the body of the whorl are beaded or granulated, the beads occurring in a series sloping downward to the right; beads seen only with a good lens; aperture not shown in the holotype. So gradually does this shell taper that in some fragments it is difficult to decide which is the basal, and which the apical end.

Holotype: (Univ. of California Coll. Paleontology) obtained near **Santa Catarina Landing,** from the upper Cretaceous beds there exposed.

Volutoderma cf. **magna** Packard

Volutoderma magna PACKARD, Univ. Calif. Publ. Geol., vol. 13, 1922, p. 432, pl. 37, fig. 1; Santa Ana Mountains, Orange County, California.

Two imperfect specimens of a *Volutoderma* were obtained from the upper Cretaceous beds near Santa Catarina Landing, which appear to be more closely related to the above species than to any other

known from the Pacific Coast, although both are somewhat narrower than the holotype at the University of California. One of the specimens from Lower California is in the Paleontological Collection of the California Academy of Sciences.

Tessarolax incrustata Anderson and Hanna, new species

Plate 9, figures 4, 5

Shell of medium size, robust, biconic; height of holotype (incomplete at base), 43 mm.; width of body-whorl, 30 mm.; height of spire, 30 mm.; spire accuminate, heavily incrusted, whorls concealed; body-whorl inflated, bicarinate, angulated at base and above it, bearing on the lower angle two or three obtuse spines, heavily incrusted; aperture broad, sub-quadrate, ending above in a long and broad ascending canal against the spire; ascending canal ending abruptly above, curving outward at its top, forming a V-shaped notch; outer lip angulated, digitate; inner lip smooth, heavily incrusted, forming at the outer margin a projecting ledge, bearing on the body-whorl a narrow nodular process, or expansion; base of body-whorl abrupt, anterior canal not shown, but apparently not much produced; entire shell encrusted as if it had been completely covered by a mantle.

Holotype: No. 4262 Mus. Calif. Acad. Sci. Paleo. from **Johnson's ranch, midway between Rosario and Santa Catarina Landing, Lower California.** Paratype, No. 4263 is from the same locality, 1430 (C. A. S.).

Tessarolax distorta Gabb is a much more slender and smaller form, has a high and narrow spire, and much longer digitate canals than the present species. It was described from the Chico beds at Tuscan Springs, Tehama County, California. "*Helicaulax*" *bicarinata* Gabb is a related species, but it has many points of difference; it was described from lower Horsetown beds near Ono, Shasta County, California.

Dentalium (Entalis) whiteavesi Anderson and Hanna, new species

Plate 6, figure 5

Entalis cooperi Whiteaves, Mes. Foss., vol. 1, pt. 2, 1879, p. 134, pl. 16, figs. 10, 10*a*; pt. 5, 1903, p. 372; (not *Dentalium cooperi* Gabb, Geol. Surv. Calif. Paleont., vol. 1, 1864, p. 139, pl. 21, fig. 100, an Eocene species).

Shell large, curved, tapering, somewhat polished, ornamented only by irregular lines of growth, without longitudinal striae; cross section nearly circular.

Holotype: No. 4252 Mus. Calif. Acad. Sci. Paleo. from **Johnson's ranch,** Loc. 1430 (C. A. S.) **between Rosario and Santa Catarina Landing, Lower California.** Its length (incomplete) is 110 mm.; width at base, 14 mm.

This species has been found at Hornby Island, and has been referred by Whiteaves to Gabb's Eocene species, *D. cooperi*, described from near San Diego, California. This species is smaller than the present form, has longitudinal striae, and a different cross section.

D. whiteavesi is also found in the upper beds of the Panoche formation near Coalinga, Fresno County, and in similar beds on the western border of the lower Sacramento Valley, north of Winters. It is not known to occur in any Eocene strata on the west coast.

Nemodon vancouverensis (Meek)

Arca vancouverensis Meek, Trans. Alb. Inst., vol. 4, 1857, p. 40; Comox, Vancouver Island.

? *Grammatodon vancouverensis* Meek, Bull. U.S. Geog. & Geol. Survey Terr., vol. 2, no. 4, 1876, p. 356, pl. 3, figs. 5, 5*a*;—White, Bull. U. S. Geol. Survey, no. 51, 1889, p. 34.

Nemodon vancouverensis Whiteaves, Mes. Foss., vol. 1, pt. 5, 1903, p. 392—Gabb, Geol. Surv. Calif. Pal., vol. 2, 1869, p. 249.

This species was originally described from the upper Cretaceous beds of Vancouver Island, but has since been found in strata of the same age in California (Coalinga), and two imperfect, although recognizable examples were obtained at the Johnson ranch, Loc. 1430 (C. A. S.); one of these is now in the paleontological collection of the California Academy of Sciences.

Aphrodina major (Packard)

Meretrix nitida Gabb, var. *major* Packard, Univ. Calif. Publ., Geol., vol. 13, 1922, p. 425, pl. 33, fig. 2; Santa Ana Mountains, Orange County, California; (not *M. nitida* Gabb, Chico and Cow Creeks, northern California).

This species is abundant and well known in the upper Cretaceous deposits in the Santa Monica and Santa Ana Mountains, southern California; at Point Loma, San Diego County, and at numerous places on the peninsula of Lower California. It seems to be more nearly related to *Aphrodina varians* Gabb, than to *Aphrodina nitida* (Gabb).

The distinctions between the two forms were indicated by Gabb, (Geol. Surv. Calif. Pal., vol. 1, 1864, p. 165).

A single specimen of this species was obtained at Loc. 1431 (C. A. S.) near Santa Catarina Landing, Lower California.

Clisocolus cordatus Whiteaves

Clisocolus cordatus Whiteaves, Mes. Foss., vol. 1, pt. 2, 1879, p. 157, pl. 18, figs. 3, 3*a*, 3*b*; pt. 5, 1903, p. 384; Nanaimo River, Vancouver Island, and nearby points.

A single specimen of this species in good state of preservation was obtained at Loc. 1431 (C. A. S.) near Santa Catarina Landing. It differs in no important characters from the form described by Whiteaves from Vancouver Island, nor from the excellent examples of the same species obtained by the California Academy of Sciences from Sucia Island, Straits of Georgia.

This species is not well known from the upper Cretaceous beds of California, although a similar but smaller species has been found by the writers.

Crassatellites tuscana (Gabb)

Astarte tuscana Gabb, Geol. Surv. Calif. Pal., vol. 1, 1864, p. 179, pl. 30, fig. 257; Tuscan Springs, Tehama County, California; vol. 2, 1869, p. 244, loc. as above.

Astarte conradiana Whiteaves (not Gabb), Mes. Foss., vol. 1, pt. 2, 1879, p. 160, pl. 18, figs. 5, 5*a*, (not fig. 6); Sucia Island, Straits of Georgia.

Cf. *Veniella crassa* Whiteaves, Mes. Foss., vol. 1, pt. 2, 1879, p. 153, pl. 18, fig. 1; Sucia Island.

A single example of this species was obtained from Johnson's Ranch, midway between Rosario and Santa Catarina Landing, Lower California.

Whiteaves seems to have recognized the form among the species he obtained from the upper Cretaceous deposits of Sucia Island, but unfortunately, the numbers on his figures seem to have been reversed (pl. 18, figs. 5, 5*a* and 6). As may be seen by referring to Gabb's figures (pl. 24, fig. 161, and pl. 30, fig. 257), *C. tuscana* is the shorter and heavier species.

The specimen from Lower California resembles very much in outline and surface markings the figure of "*Veniella crassa*" Whiteaves.

Spondylus cf. rugosus Packard

Spondylus rugosus Packard, Univ. Calif. Publ. Geol., vol. 13, 1922, p. 422, pl. 26, fig. 3; pl. 29, fig. 3; pl. 30, fig. 3; "Chico group," Santa Ana Mountains, Orange County, California.

Two badly weathered specimens of a *Spondylus* were obtained from the upper Cretaceous beds near Santa Catarina Landing. They appear to be referable to the above species described by Packard, having the numerous radiating ribs and the fine crenulations on the interior of the lower margin, as noted in his description. They are, however, of the size, form and general aspect of the species described by the same author as *Spondylus striatus*, for which no inner crenulations were mentioned in the description.

Inoceramus pacificus Anderson and Hanna, new species

Plate 10, figure 4

Cf. *Inoceramus cripsianus* (Mantell), Stoliczka, Cret. Fauna S. India, vol. 3, 1871, p. 405, pl. 27, figs. 1, 1*a;* Arrialoor group, southern India.

Shell large, sub-quadrate, elongate, beaks almost terminal, strongly incurved; hinge margin extended, straight, elevated behind; anterior end abrupt, slightly rounded below; basal margin broadly rounded in outline; surface bearing strong concentric undulations on the upper half, becoming obsolete below. Length of holotype, 142 mm.; height 88 mm.; thickness 70 mm. (estimated).

Holotype: No. 4266, Mus. Calif. Acad. Sci. Paleo. from Loc. 1430, (C. A. S.) **Johnson's ranch, midway between Rosario andSanta Catarina Landing.**

Zittel[28] has given many illustrations of *Inoceramus cripsii* Mantell showing extraordinary variations of the European form and a long list of names regarded by him as synonymous. Under the name *Inoceramus cripsianus* (Mant.), Stoliczka[29] has figured an Indian species as representing the same. Although the peninsular species clearly belongs to the group of *I. cripsii* Mant. it scarcely comes within the range of variations shown by Zittel. It resembles more nearly Stoliczka's Indian form, although it is less produced in front, and the undulations on the sides do not extend so low as in the latter. It is therefore regarded as a distinct species, although further discoveries may prove the contrary, or that it is identical with the Indian form. There is also some resemblance between our species and *I. pembertoni* Waring, but in the latter the beaks are high and terminal.

Inoceramus whitneyi Gabb

Inoceramus whitneyi Gabb, Geol. Surv. Calif. Pal., vol. 2, 1869, pp. 193, 247, pl. 32, fig. 91; Chico group, Folsom, California;—Anderson, Proc. Calif. Acad. Sci., ser. 3, vol. 2, 1902, pp. 31, 34, 37, etc.—Waring, Proc. Calif. Acad. Sci., ser. 4, vol. 7, 1917, p. 62, pl. 8, fig. 9; Calabasas, California.—Stanton (in Darton) Jour. Geol., vol. 29, 1921, p. 727; Lower California.

This species is very well known in the upper Cretaceous of California, occurring abundantly in its upper division. It has been found at various places in Lower California, including the Johnson ranch, north of Santa Catarina Landing and at neighboring points. A very similar, if not identical form has been found in upper Cretaceous beds of Sucia Island, which is now in the paleontological collection of the California Academy of Sciences.

Attention may be called here to the resemblance in form, size and surface ornamentation of this species and *Inoceramus subundatus* (Meek)[30] and to the discussion of the latter species by Whiteaves.[31] This latter species was described from Sucia Island, Straits of Georgia. In the collections of the California Academy of Sciences there are several good specimens of Meek's species from this locality, and also many well-preserved specimens of *I. whitneyi* Gabb, from various localities in California. A comparison of these examples shows very clearly their close relationship, and at least their analogy, although the northern form appears to be somewhat more inflated.

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[28] Karl A. Zittel, Denkschr. d. K. Akad. Wiss., Wien., vol. 25, 1866, pt. 2, p. 95, pls. 14, 15.
[29] F. Stoliczka, Cret. Fauna S. Ind., vol. 3, 1871, p. 405, pl. 27, figs. 1, 1*a*.
[30] F. B. Meek, Bull. U. S. Geol. & Geog. Surv. Terr., vol. 2, no. 4, 1876, p. 358, pl. 3, figs. 1, 1*a*, 3, 3*a*.
[31] J. F. Whiteaves, Mes. Foss. vol. 1, pt. 2, 1879, p. 172; pt. 5, 1903, p. 397.

Corbis peninsularis Anderson and Hanna, new species

Plate 10, figure 1

Shell moderately inflated, almost circular in outline, smooth, without radial markings on the surface; surface marked only by evenly spaced concentric lines of growth; umbones low, curving forward, not widely separated; lunule obsolete or absent; posterior margin rounded; dentition not shown. Length 60 mm.; height 60 mm.

Holotype: Univ. Calif. Coll. from Loc. 467, **midway between Ensenada and San Quintin, Lower California;** collected by Ings. Barrera and Santillán.

Opis rosarioënsis Anderson and Hanna, new species

Plate 10, figures 2, 3

Shell subtriangular, broadly rounded at the base, straight on anterior border, rounded behind; umbones strongly incurved; lunule deep, ovate in outline, bordered within by an impressed marginal groove, bordered without by a slightly broader, almost smooth area surrounded by a thin raised lamella; holotype (broken on lower margin) measuring 2.3 inches (5.8 cm.) in length; 2.6 inches (6.6 cm.) in height; depth of single valve one inch (2.54 cm.); lunule 0.9 inch (2.3 cm.) in height; surface marked by flattened area behind, forming a strong umbonal ridge; strong concentric lines of growth, and anterior extra-lunular area; dentition not shown.

Holotype: Univ. Calif. Coll. from Loc. A-426, **near Rosario Landing, Lower California,** collected by Ings. Barrera and Santillán.

Coralliochama orcutti White

Coralliochama orcutti White, U. S. Geol. Survey, Bull. 22, 1885, p. 10, pls. 1, 2, 3, 4; Todos Santos Bay, Lower California.—Fairbanks, Am. Jour. Sci., ser. 3, vol. 45, 1893, pp. 474, 475, 477, etc.—Anderson, Proc. Calif. Acad. Sci., ser. 3, vol. 2, 1902, pp. 38, 75.

This species was first described from Todos Santos Bay, Lower California, but has since been found at Point Loma, La Jolla, and at other points, and is reported from as far north as the Mendocino coast of California.

Good specimens were obtained by Chas. H. Sternberg at Johnson's ranch, midway between Rosario and Santa Catarina Landing, and are now in the paleontological collection of the California Academy of Sciences.

Although the species has been reported from the lower Chico beds of the Cottonwood district, Shasta County, a comparison of specimens recently found there with excellent examples from the type locality do not support the view as to their identity.

Plate 1

Fig. 1. *Parapachydiscus catarinae* Anderson & Hanna, new species. Holotype, No. 4245 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 503 mm.; p. 19.

Plate 2

Fig. 1. *Parapachydiscus catarinae* Anderson & Hanna, new species. Paratype, No. 4246 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 190 mm.; p. 19.

Plate 3

Fig. 1. *Parapachydiscus catarinae* Anderson & Hanna, new species. Paratype, No. 4246 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; thickness 77 mm.; p. 19.

Fig. 2. *Parapachydiscus catarinae* Anderson & Hanna, new species. Paratype, No. 4247 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 79 mm.; p. 19.

Fig. 3. *Parapachydiscus catarinae* Anderson & Hanna, new species. Paratype, No. 4247 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; thickness 36 mm.; p. 19.

Plate 4

Fig. 1. *Parapachydiscus peninsularis* Anderson & Hanna, new species. Holotype, No. 4248 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 355 mm.; p. 20.

Plate 5

Fig. 1. *Parapachydiscus peninsularis* Anderson & Hanna, new species. Paratype, No. 4249 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; thickness 66 mm.; p. 20.

Fig. 2. *Parapachydiscus peninsularis* Anderson & Hanna, new species. Paratype, No. 4249 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 117 mm.; p. 20.

Plate 6

Fig. 1. *Parapachydiscus ootacodensis* (Stoliczka). Plesiotype, No. 4251 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 76 mm.; p. 20.

Fig. 2. *Parapachydiscus ootacodensis* (Stoliczka). Plesiotype, No. 4251 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; thickness 33 mm.; p. 20.

Fig. 3. *Parapachydiscus peninsularis* Anderson & Hanna, new species. Paratype, No. 4250 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 41.5 mm.; p. 20.

Fig. 4. *Parapachydiscus peninsularis* Anderson & Hanna, new species. Paratype, No. 4250 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; thickness 26 mm.; p. 20.

Fig. 5. *Dentalium* (*Entalis*) *whiteavesi* Anderson & Hanna, new species. Holotype, No. 4252 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; length 110 mm.; diameter at base, 14 mm.; p. 27.

Plate 7

Fig. 1. *Nostoceras sternbergi* Anderson & Hanna, new species. Holotype, No. 4254 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; length 109 mm.; p. 22.

Fig. 2. "*Hamites*" *vancouverensis* Gabb. Plesiotype in University of California coll. from Santa Catarina Landing, Lower California; p. 23.

Fig. 3. "*Hamites*" *vancouverensis* Gabb. Same specimen as fig. 2; thickness 29 mm.; p. 23.

Fig. 4. "*Hamites*" *vancouverensis* Gabb. Cross section of same specimen as fig. 2; p. 23.

Fig. 5. *Parapachydiscus peninsularis* Anderson & Hanna, new species. Paratype, No. 4253 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter 89 mm.; thickness 55 mm.; p. 20.

Plate 8

Fig. 1. *Baculites inornatus* Meek. Plesiotype, No. 4258 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; diameter in center 44 mm.; length 140 mm.; p. 24.

Fig. 2. *Baculites inornatus* Meek. Cross section of specimen shown in fig. 1; *s* indicates position of siphon; p. 24.

Fig. 3. *Baculites occidentalis* Meek. Plesiotype in University of California coll. from Santa Catarina Landing, Lower California; p. 24.

Fig. 4. *Baculites occidentalis* Meek. Cross section of specimen shown in fig. 3; *s* indicates position of siphon; p. 24.

Fig. 5. "*Hamites*" *vancouverensis* Gabb. Plesiotype in University of California coll. from Santa Catarina Landing, Lower California; length of fragment 85 mm.; p. 23.

Plate 9

Figs. 1, 2, 3. *Turritella parallela* Anderson & Hanna, new species. Three photographs of a block containing numerous specimens; holotype, the sculptured shell of fig. 3, length 17.5 mm.; from Santa Catarina Landing, Lower California, now in the University of California coll.; p. 26.

Fig. 4. *Tessarolax incrustata* Anderson & Hanna, new species. Holotype, No. 4262 (C. A. S. Paleo. type coll.) from Johnson's Ranch between Rosario and Santa Catarina Landing, Lower California; height 43 mm.; p. 27.

Fig. 5. *Tessarolax incrustata* Anderson & Hanna, new species. Same specimen as fig. 4; p. 27.

Plate 10

Fig. 1. *Corbis peninsularis* Anderson & Hanna, new species. Holotype in University of California coll., from midway between Ensenada and San Quintin, Lower California; height 60 mm.; p. 31.

Fig. 2, 3. *Opis rosarioënsis* Anderson & Hanna, new species. Holotype in University of California coll., from near Rosario Landing, Lower California; length 58 mm.; thickness of single valve 25.4 mm.; p. 31.

Fig. 4. *Inoceramus pacificus* Anderson & Hanna, new species. Holotype, No. 4266 (C. A. S. Paleo. type coll.) from midway between Rosario and Santa Catarina Landing, Lower California; length 142 mm.; p. 29.

Fig. 5. *Turritella peninsularis* Anderson & Hanna, new species. Holotype, No. 4709 (C. A. S. Paleo. type coll.) from Santa Catarina Landing, Lower California; length 61 mm.; maximum width 21.6 mm.; p. 25.

Plate 11

Fig. 1. Exposures of chert strata (? pre-Cretaceous); Dearing Canyon, middle of east side of Cedros Island, Lower California; looking south, showing dip to southwest.

Fig. 2. Exposure of strata (? upper Cretaceous) on west side of Natividad Island, Lower California; looking southeast, showing dip to southwest.

Fig. 3. Sedimentary strata (? upper Cretaceous), Margarita Island, Lower California; looking northeast, showing steep dip to southwest.